ELEC 403 --- Lab 2

This script is used to fulfill the requirements of the lab in ELEC 403.

generate s[n]

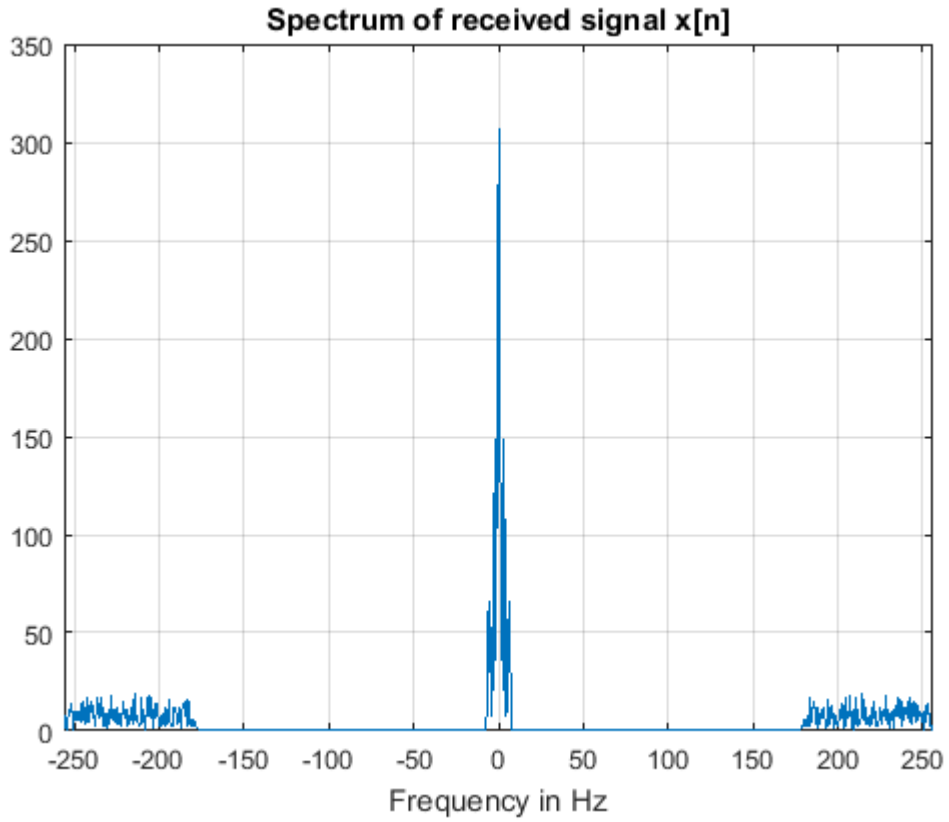
```
t = 0:1/512:(2-1/512);
t = t(:);
randn('state', 7)
a = 0.2*randn(7,1);
randn('state', 19)
b = 0.2*randn(7,1);
s = 0.3*ones(1024,1);
for i = 1:7,
 s1 = a(i)*sin(2*pi*i*t);
 s2 = b(i)*cos(2*pi*(i-0.5)*t);
 s = s + s1 + s2;
end
```

generate w[n]

```
randn('state',9); % sets a seed state for generating a random sequence
w0 = randn(1024,1); % generate 1024 Gaussian white random samples
mw = mean(w0); % evaluate its mean value
w0 = w0 - mw; % modify w0 to have a zero-mean
c = 0.3/sqrt((w0'*w0)/1024);
w0 = c*w0; % modify w0 to have a standard deviation = 0.3
h = fir1(250,0.7,'high'); % get a good highpass FIR filter with cutoff freq. = 0.7
w1 = conv(h,w0); % apply highpass filtering to the white noise sequence
w = w1(126:1149); % cut the filtered sequence to a right size
w = w(:); % make sure w[n] is a column vector
```

Plot recieved signal x[n]

```
x = s + w;
xf = fft(x); % perform FFT of signal x[n]
xf = fftshift(xf); % shift zero-frequency component to center of spectrum
f = -256:512/1023:256; % define an appropriate frequency axis for plotting
plot(f,abs(xf))
axis([-256 256 0 350])
grid
xlabel('Frequency in Hz')
title('Spectrum of received signal x[n]')
%print('Prod272_4','-dpng','-r600')
```

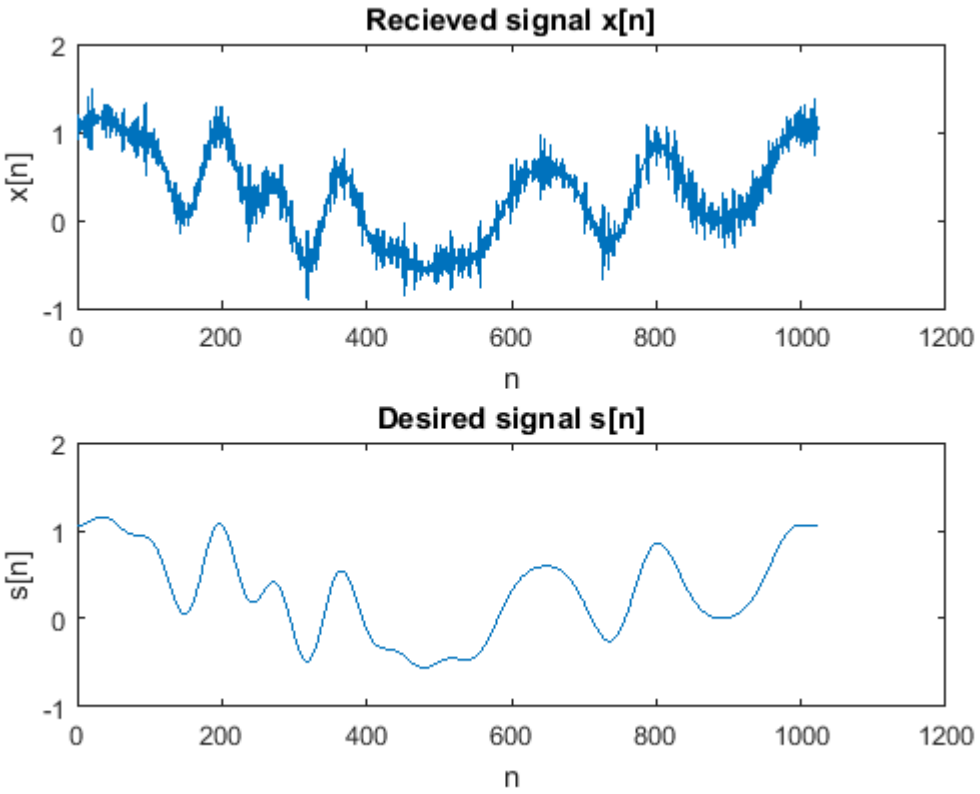


2.6.1

```
fprintf('Starting 2.6.1\n')
subplot(2,1,1);
x = s + w;
L = length(x);
n=1;
plot(n:L,x);
title('Recieved signal x[n]')
```

```
xlabel('n')
ylabel('x[n]')
subplot(2,1,2);
plot(n:L,s);
title('Desired signal s[n]')
xlabel('n')
ylabel('s[n]')
%print('Prod271','-dpng','-r600')
```

```
Starting 2.6.1
```

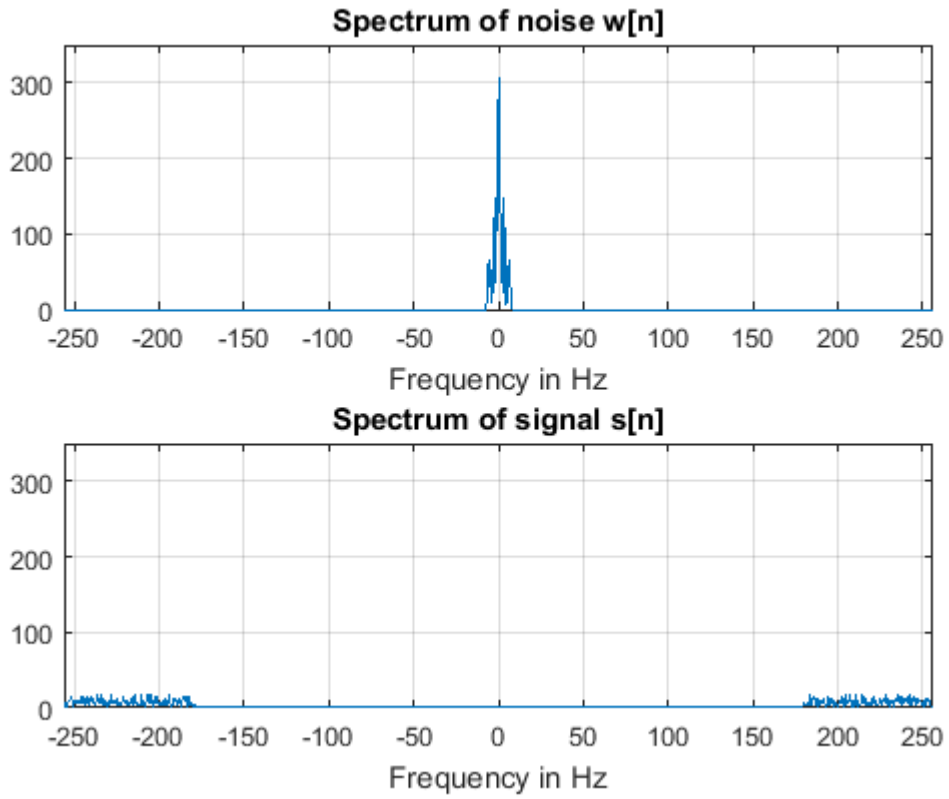


2.6.2 discrete Fourier Transform for s[n] and w[n]

```
fprintf('Starting 2.6.2\n')
subplot(2,1,1);
sf = fft(s); % perform FFT of signal s[n]
sf = fftshift(sf); % shift zero-frequency component to center of spectrum
f = -256:512/1023:256; % define an appropriate frequency axis for plotting
plot(f,abs(sf))
axis([-256 256 0 350])
grid
xlabel('Frequency in Hz')
title('Spectrum of noise w[n]')
```

```
subplot(2,1,2);
wf = fft(w); % perform FFT of signal w[n]
wf = fftshift(wf); % shift zero-frequency component to center of spectrum
f = -256:512/1023:256; % define an appropriate frequency axis for plotting
plot(f,abs(wf))
axis([-256 256 0 350])
grid
xlabel('Frequency in Hz')
title('Spectrum of signal s[n]')
%print('Prod272_1','-dpng','-r600')
```

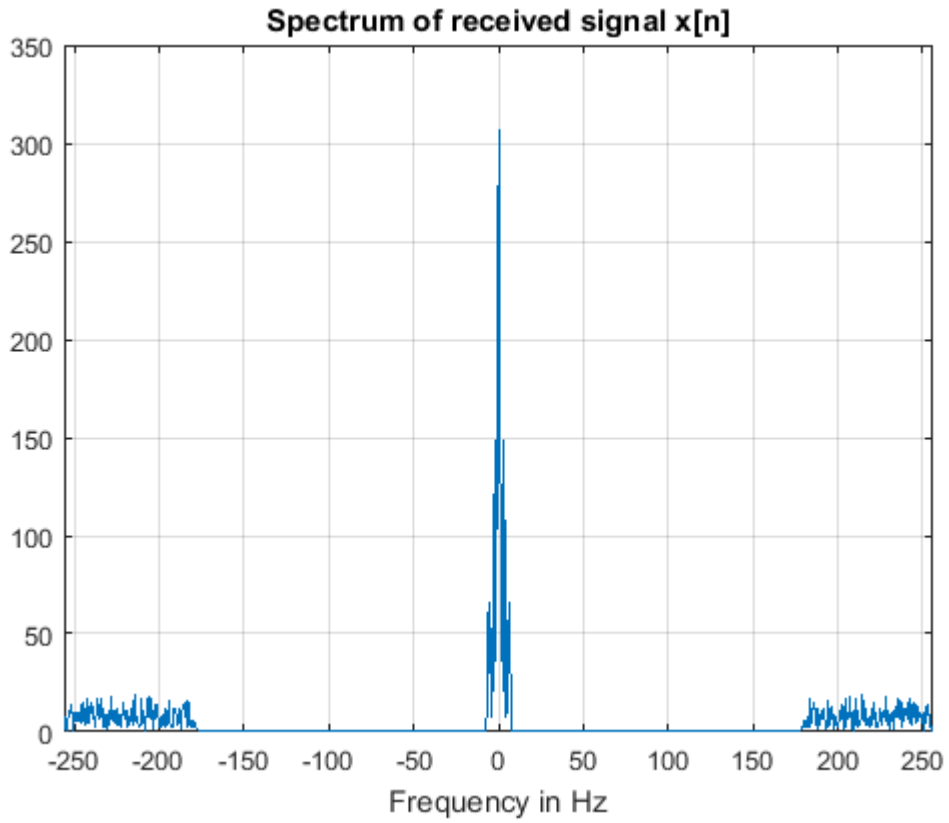
```
Starting 2.6.2
```



Plot recieved signal x[n]

```
x = s + w;
xf = fft(x); % perform FFT of signal x[n]
xf = fftshift(xf); % shift zero-frequency component to center of spectrum
figure % make new figure instead of a subplot
f = -256:512/1023:256; % define an appropriate frequency axis for plotting
plot(f,abs(xf))
axis([-256 256 0 350])
grid
```

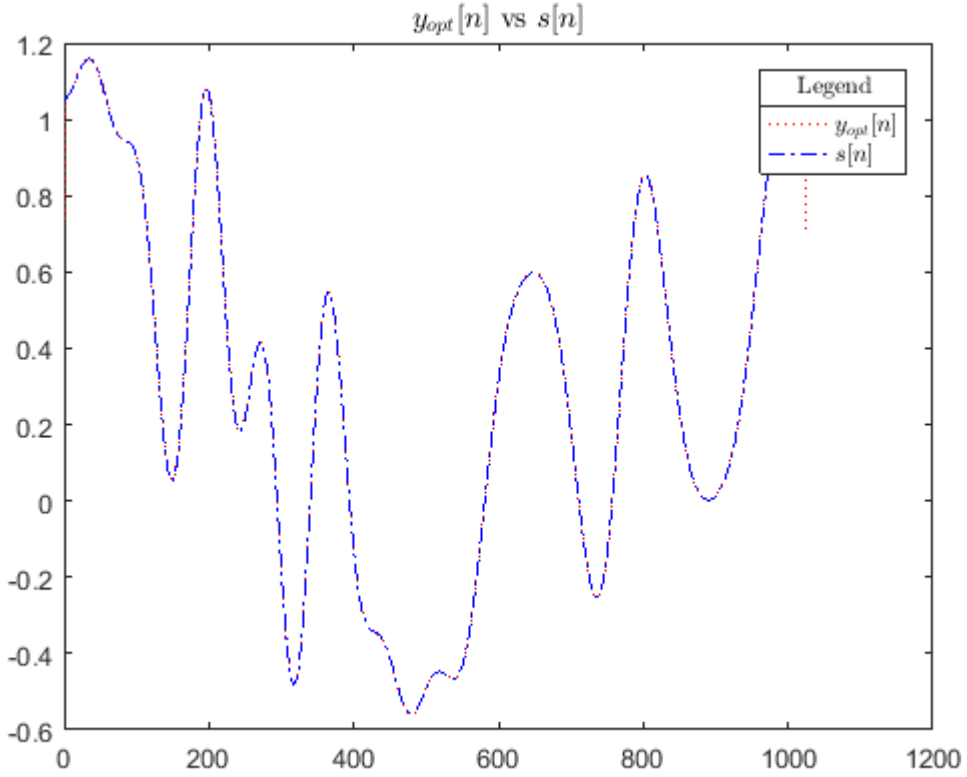
```
xlabel('Frequency in Hz')
title('Spectrum of received signal x[n]')
%print('Prod272_2','-dpng','-r600')
```



2.6.3

```
fprintf('Starting 2.6.3\n')
h=[0.07319357 0.25 0.3561286 0.25 0.0731967];
y = conv(x,h,'same'); % sames crops unneccessary entries.
L= length(y);
plot(n:L,y,':r');
hold on
plot(n:L,s,'-.b');
lgd = legend('$y_{opt}[n]$','$s[n]$');
title(lgd,'Legend')
title('$y_{opt}[n]$ vs $s[n]$','Interpreter','latex')
set(lgd,'Interpreter','latex')
```

```
Starting 2.6.3
```



2.6.4 SNRb is the Signal to Noise Ratio before and SNRa is the Signal to Noise Ration after filter is applied

```
fprintf('Starting 2.6.4\n')
SNRb = 20 *log10(norm(s)/norm(x-s));
SNRa = 20 *log10(norm(s)/norm(y-s));
fprintf('The Signal to Noise Ration before is: %2.4f\n',SNRb)
fprintf('The Signal to Noise Ration after is: %2.4f\n',SNRa)
```

```
Starting 2.6.4
The Signal to Noise Ration before is: 11.5701
The Signal to Noise Ration after is: 31.8072
```

2.6.5

```
fprintf('Starting 2.6.5\n')
womega = [0.3 0.6 0.9];
n=1;
for i=1:3
    figure
    fprintf('Interation %1d\n',i)
    h(i,:)= fir1(4,womega(i));
```

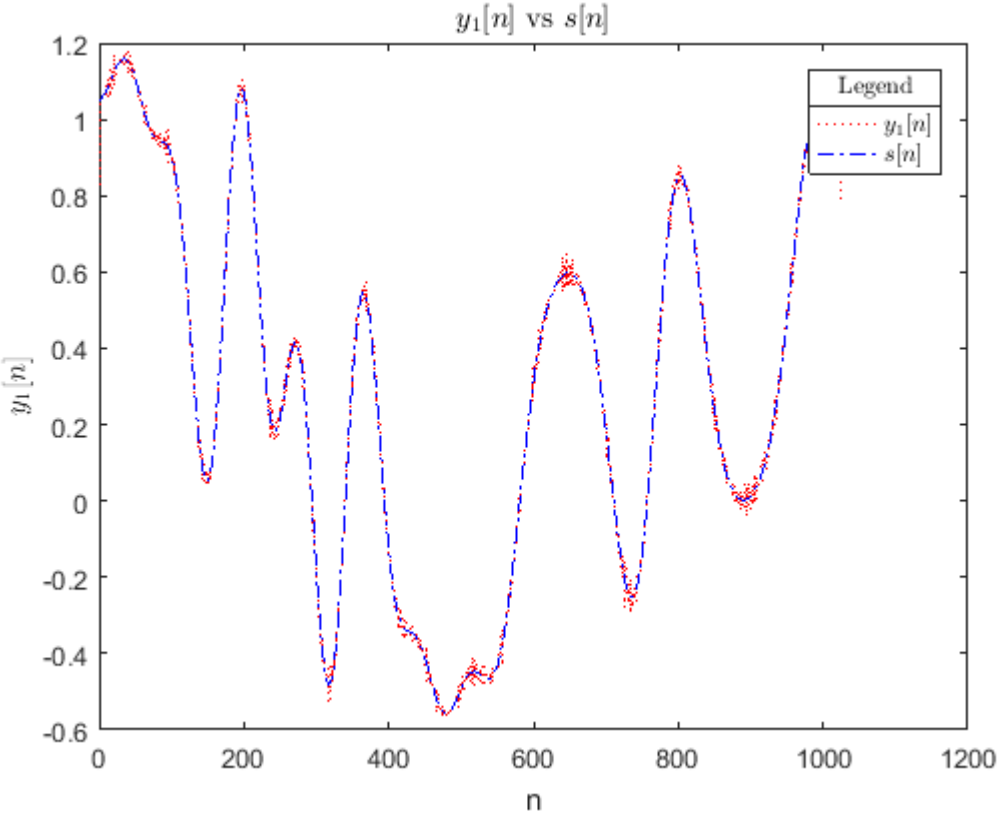
```
    y=conv(x,h(i,:),'same');
    SNRbefore(i) = 20 *log10(norm(s)/norm(x-s));
    SNRafter(i)  = 20 *log10(norm(s)/norm(y-s));
    plot(n:L,y,':r');
    hold on
    plot(n:L,s,'-.b');
    plotname =sprintf('$y_%d[n]$', i);
    lgd = legend(plotname,'$s[n]$');
    title(lgd,'Legend')
    titlename = sprintf('%s vs $s[n]$',plotname);
    title(titlename,'Interpreter','latex')
    xlabel('n');
    ylabel(plotname,'Interpreter','latex');
    set(lgd,'Interpreter','latex')
    fname = sprintf('Prod275%d', i);
    print(fname,'-dpng','-r600')
end
T = table(womega(:),SNRbefore(:),SNRafter(:));
T.Properties.VariableNames = {'AngularFrequency' 'SignaltoNoiseRatioBefore'
'SignaltoNoiseRatioAfter'}
```

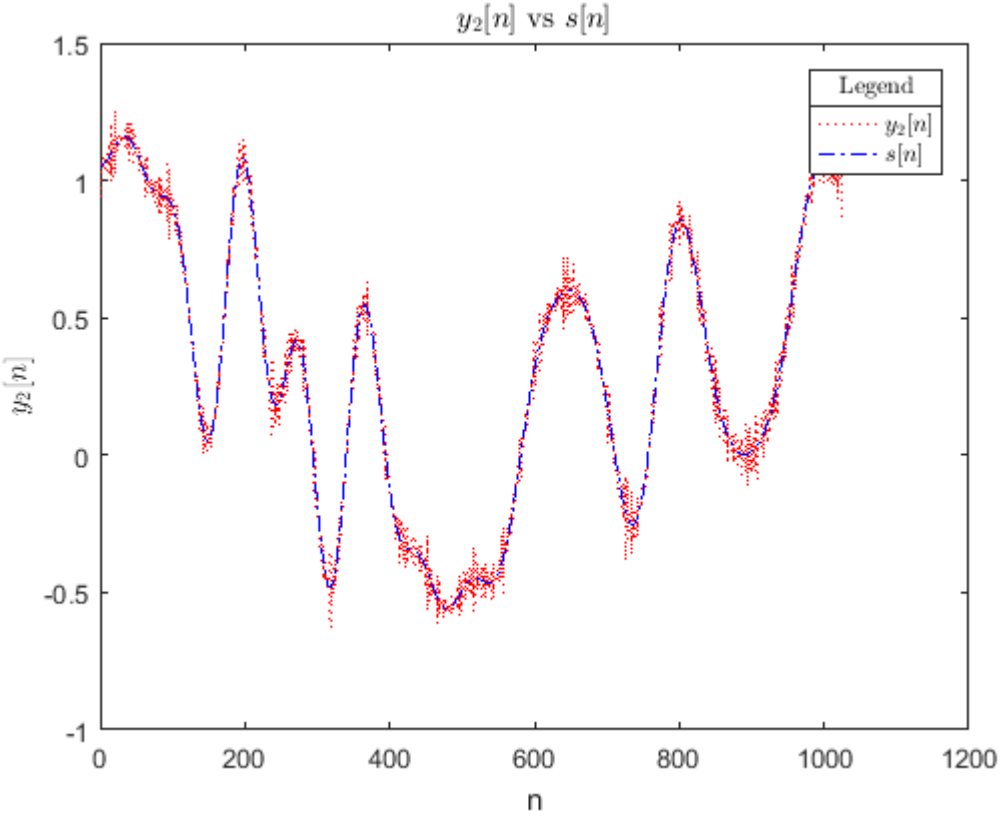
```
Starting 2.6.5
Interation 1
Interation 2
Interation 3

T =

    AngularFrequency    SignaltoNoiseRatioBefore    SignaltoNoiseRatioAfter
    ________________    ________________________    _______________________

    0.3                 11.5700600694238            28.3447550455541
    0.6                 11.5700600694238            20.8126782853119
    0.9                 11.5700600694238            13.4309113832353
```


$y_1[n]$ vs $s[n]$
Legend
$y_1[n]$
$s[n]$
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
$y_1[n]$
0
200
400
600
800
1000
1200
n


$y_2[n]$ vs $s[n]$
Legend
$y_2[n]$
$s[n]$
1.5
1
0.5
0
-0.5
-1
0
200
400
600
800
1000
1200
n
$y_2[n]$